Carnarvon One Mile Jetty

Assessment of Remaining Jetty

And Pile Testing

31 August 2022

Prepared by

Trinacria Consulting

Prepared for and on behalf of

Ventia

Report 0801/2022

Carnarvon One Mile Jetty – Assessment of Remaining Jetty

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Executive Summary

The historic Carnarvon One Mile Jetty was badly damaged by Cyclone Seroja in 2021. Debris from the damaged jetty was deemed a hazard to navigation and the decision was made to demolish what remained of the section of jetty in the ocean from Piers 114 to 248.

The section of the jetty within the mangrove area between Piers 1 and Pier 70 was not impacted by the cyclone. This area has experienced extensive siltation and the growth of mangroves since the jetty was first constructed in 1898. Therefore, it is only inundated with water during high tides. The shallow water and mangroves combine to protect this portion from cyclonic waves.

The section of jetty between Piers 71 and 100 is in an intertidal lagoon. This portion is in very poor condition. Any debris resulting from collapse due to wind or rotting timber would likely be trapped in the intertidal area and therefore not pose a risk to navigation.

Within the community and the CHG there is some degree of desire to retain at least some portion of the original structure in addition to constructing a new jetty.

As the structural integrity of the jetty is heavily dependent upon the condition of the piles, DoT engaged Ventia and Trinacria Consulting to undertake pile testing of a random selection of piles principally to determine, if possible, the degree of damage due to marine borers and report on the feasibility of maintaining a section of jetty for pedestrian access only. Marine borers were found to be a contributing factor to the collapse of the jetty during the cyclone.

Random coring of piles found the presence of marine borers where the coring was possible in the zone where marine borers operate i.e., between the seabed and mean sea level. While marine borers were not found in the piles located in the silted areas (Piers 1 to 70) the coring was above MSL due to access constraints. It is however highly likely that marine borers were active at lower levels prior to the siltation occurring. Fifty percent (50%) of the piles in this zone were replaced between 1898 and 1960 during times when the ground level was below MSL therefore it is likely that marine borers were partially to blame. Some piles in this section will therefore require replacement.

The inspection found that there are numerous other issues that must be attended to should a portion of the jetty be reopened for pedestrian access only. These include complete replacement of the timber decking, reinstatement of cross bracing and lower waling members, replacement of some stringers, replacement of corroded bolts and repairs to handrailing.

1 Introduction

Cyclone Seroja passed to the west of Carnarvon on Sunday 11th April 2021. The seas and swell resulting from the cyclone coupled with the storm surge wreaked havoc on the historic One Mile Jetty which extends approximately 1450 m out to sea from Babbage Island. The maximum wind gust recorded at Carnarvon was 107 km/hr at 1246 on Sunday 11th April 2021.

The jetty, which is under the custodianship of the Carnarvon Heritage Group (CHG) had been closed to the public since 2017 following a condition assessment and recommendations by consultant's MP Rogers and Associates (MPR).

Cyclone Seroja also caused damage to the old disused Prawning Jetty located approximately 900m SE of the One Mile Jetty.

The Department of Transport (DoT), who is responsible for marine safety, engaged Ventia and Trinacria Consulting (subconsultant to Searle Consulting) to undertake an inspection of the jetty and report on the level of damage. The inspection was undertaken on 21st and 22nd April 2021 by Nello Siragusa (Trinacria Consulting), Jimmy Seng and Gabriel Jackson (Ventia). The findings of that inspection and recommendations are detailed in Trinacria Consulting Report 2021/0401.

The report concluded that principal failure mode was wave uplift removing the timber decking, weakened timber piles snapping at mid tide level due to rot and marine borer attack and split timber corbels rendering the bolts securing the stringers to the corbels ineffective.

The report recommended that the section of jetty between Pier 70 and Pier 245 (Jetty head) be demolished to prevent risks to safe navigation from timber debris. The first 420m section of jetty (Piers 1 to 70) is in the mangroves and suffered little impacted from the cyclonic waves due to limited water depth and the presence of mangroves.

Subsequently Piers 114 to 245 (end of the jetty) were deconstructed, and salvaged timber stored in the CHG yard near the jetty abutment. Piers 70 to 114 were in a lagoon and beach area and not deemed a potential hazard to navigation at that time therefore were not demolished.

Within the community and the CHG there is some degree of desire to retain at least some portion of the original structure in addition to constructing a new jetty.

As the structural integrity of the jetty is heavily dependent upon the condition of the piles, DoT engaged Ventia and Trinacria Consulting to undertake pile testing of a random selection of piles principally to determine, if possible, the degree of damage due to marine borers and report on the feasibility of maintaining a section of jetty for pedestrian access only.

Teredo is not visible from the outside of the pile unless the pile is badly degraded. To test for the presence of marine borers it is necessary to take a core sample from the pile. Teredo is a marine borer which is active in the water column portion of the pile (i.e., from seabed to approximately Mean Sea Level (MSL). Evidence of Teredo was found in the demolished section of the jetty.

The inspection and pile testing was undertaken between 9th and 11th August 2022.

2 Jetty Arrangement

Inspection of piles retrieved during the deconstruction and those washed ashore immediately following the cyclone revealed the presence of Teredo in addition to rot and splitting between the seabed and mean sea level (MSL), i.e., the portion of pile immersed in the water column. The section of pile in the atmospheric zone (between MSL and top of pile) and pile permanently below seabed was generally sound as marine organisms cannot thrive in those areas.

The jetty approach generally consists of a pair of raker piles at each pier with piers spanning 20 feet (6.1 m). The piles are braced with a pair of timber cross braces and lower waler located just above Mean Low Water Spring tide level (MLWS). Timber crossheads at the top of the pile support timber corbels which in turn support the timber beams (stringers). The jetty deck comprises 9" x 3" timber planks. A breakdown of the material and sizes is shown in Table 1 and a schematic of the jetty approach is shown in Figure 1.

Item	Material	Length m
Piles	Timber average dia 15 inches Penetration 15 ft Cut off level 14.25 ft	9
Crossheads	Timber 12" x 6"	4
Stringers (Beams)	Timber 12" x 6"	6.1
Corbels	12"x12" & 12"x 6"	1.8
Cross Braces and Walings	Timber 12'' x 6"	6
Decking	Timber 9" x 3"	4
Hand Rails	Timber 4" x 4" stanchions at 6ft Centres 4"x 4" Top rail 4"x 2" Mid rail	6

Table 1: Typical material sizes and quantities per Pier - Jetty Approach

The first 400m of jetty (Pier 1 to Pier 70) is heavily silted and surrounded by mangroves. Anecdotal evidence suggests that the water depth near the jetty abutment was historically deep enough to allow swimming and jumping into the water from the jetty deck. Closure of the south arm of the Gascoyne River and the growth of mangroves may have contributed to the silting of the first 400m to the point where the area is dry except during high tides. Consequently, the jetty in this section is as shown schematically in Figure 2 and Photo 1 and Photo 2.

Silting in this area is confirmed by comparing the 1897 survey with the 1960 and 1961 survey (Refer Drawing PWD.WA38794-01-01) and Figure 3.

While the exposed section of pile in this area is generally sound there is a high likelihood that the buried section of pile between the existing natural surface and the original seabed has been affected by marine organisms including Teredo. Teredo require the presence of both water and oxygen hence only that portion of the pile in the water column will be affected. The braced portal design means that the maximum pile stress will occur just below lower waler level i.e., in the area likely impacted by rot and teredo prior to siltation.

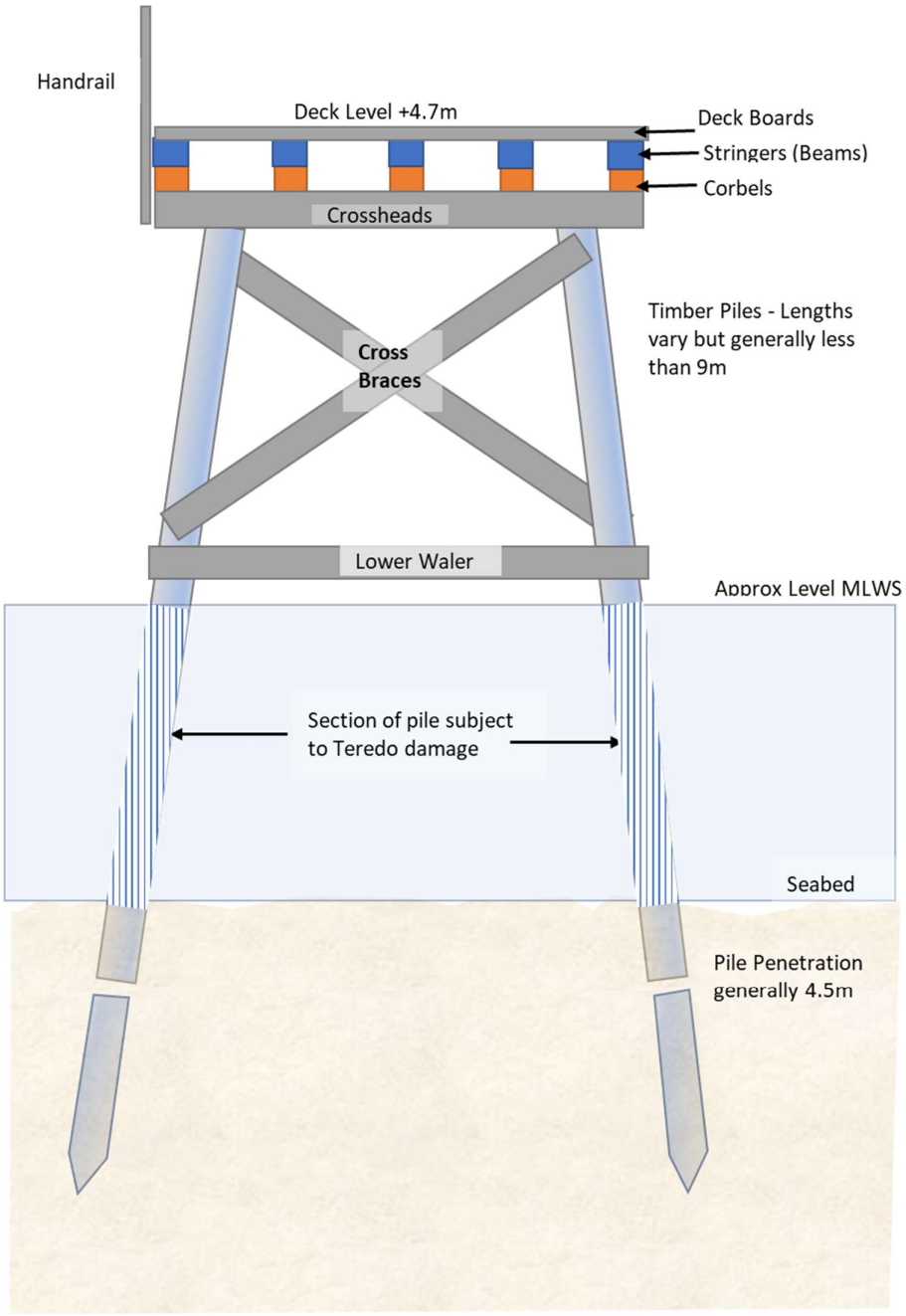

Figure 1: Typical Pier Arrangement - Jetty Approach – prior to silting highlighting areas subject to damage by marine borers

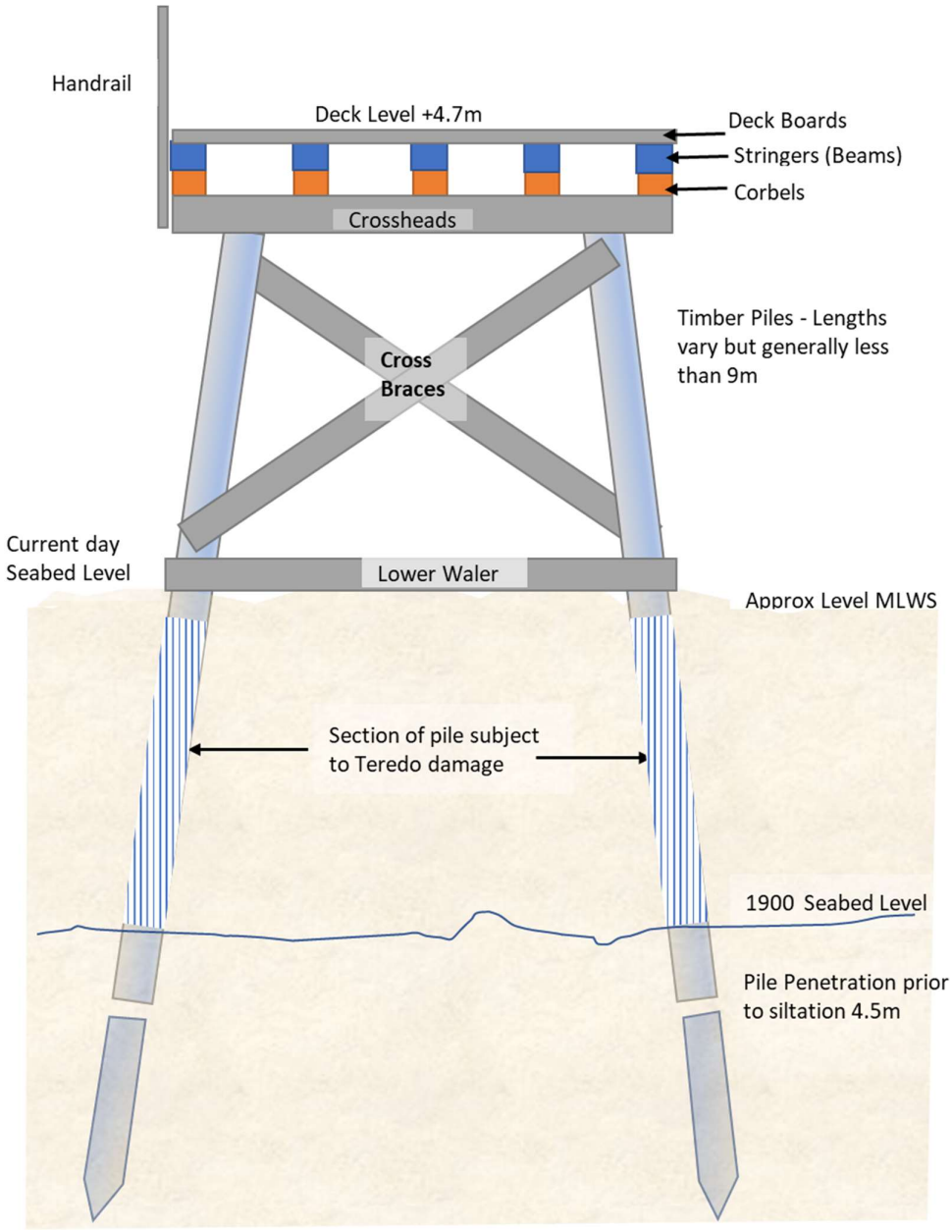

Figure 2: Cross Section Piers 1 to 70 following siltation.

Photo 1: Jetty approach - approximately Pier 10 showing degree of siltation

Photo 2: Jetty approach showing piles replaced circa 1950

The above photos show that many of the jetty piles were replaced during its lifetime. Markings on the piles show that some of these piles were replaced in the 1950's. This is confirmed by reviewing archived Drawings PWD.WA 25272. The presence of the pile stump would suggest that the pile was cut off just above water level after the replacement pile was installed. Examination of the bolt holes in the crosshead also suggests that crossheads were also replaced in some instances.

A review of historical records (PWD.WA 25272-01-01) shows that 50% of the piles between Piers 1 and 70 were replaced or repaired by splicing between 1920 and 1961 . This percentage is higher for the offshore section. The reason for replacement of piles in this zone is most likely due to marine borer attack, rotting or split piles. As previously mentioned, this is commensurate with the expected life of a timber pile in the marine environment when marine borers are present.

This would suggest that the piles that were replaced had a life of approximately 50 years which is typical for timber structures in the marine environment. It is not known why the piles were replaced however it is highly probable that the piles were affected by marine borers and rot. As the buried section of pile was likely to be sound due to the lack of oxygen. Extraction of the pile would be problematic as it would likely snap at the seabed or within the areas in the water column hence it would be a logical decision to cut the pile rather than attempt extraction.

The pile replacement/repair plans state that pile treatment for the replacement piles was "charred and tarred". The efficacy or life of this type of treatment is not known, particularly in relation to deterring marine borers, however it is likely that any treatment within the water column would be washed away over a period of time. The remnants of the charring and tarring process can be seen on the black staining on the piles in the photos below.

Photo 3: Pile replaced circa 1950 showing remnant black pile "charred and tarred" treatment

Photo 4:Pile replaced circa 1950 showing remnant black pile treatment. Remains of original pile still attached to crosshead.

Photo 5: Piles replaced circa 1950 showing remnant black stains from the charring and tarring treatment

Photo 6: Replaced pile showing black remnants of pile treatment

Photo 7: Replaced pile showing markings - 44 indicates year of replacement (1944) and roman numerals XXVI indicates length of pile at 26 feet.

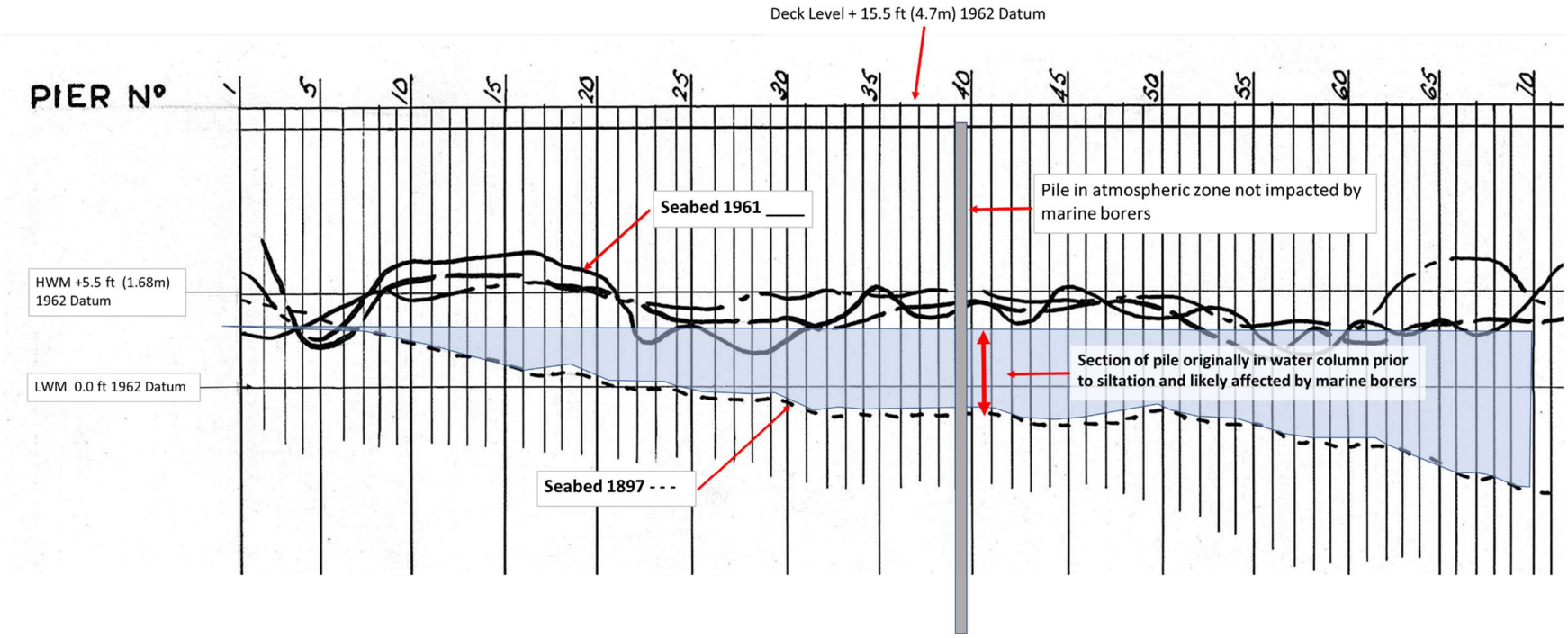

Figure 3: Comparison of seabed profiles between 1897 and 1961 between Piers 1 to 70 showing level of siltation and likely areas of marine borer infestation prior to siltation.

Comparison of the 1897 survey and the 1961 survey (Ref PWD.WA 38794-1-1) shows that siltation between Piers 1 and 70 varies between almost zero at the abutment and 2.6m at Pier 70. It is likely that siltation has continued since the 1961 survey due to the growth of mangroves.

It is highly probable that piles in this location have been impacted by marine borers in the section previously inundated with water.

3 Pile Testing

Core samples were taken from randomly selected piles using a 50mm core drill penetrating the pile at an angle of 45 degrees. This method was adopted to avoid the need for deep excavations which would fill with water. Coring operations were planned to occur at periods of low tides to facilitate excavation.

A schematic of the methodology is shown in Figure 4. Photo 8 shows the coring operation. Cored holes were plugged with a 50mm wooden dowel.

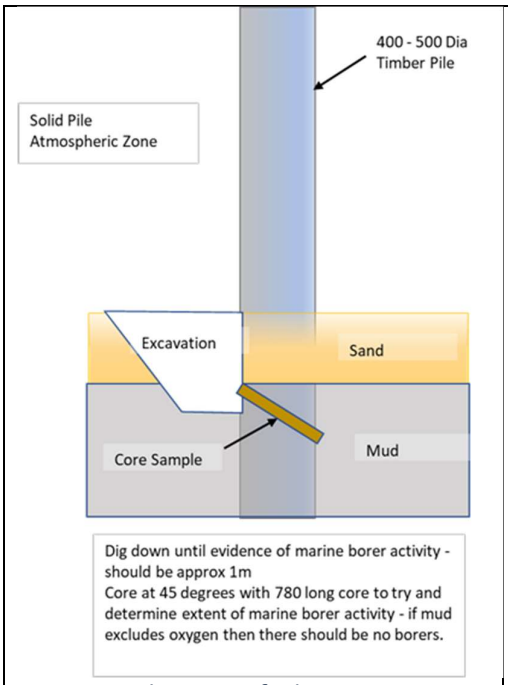

Figure 4: Schematic of pile coring methodology

Photo 8: Pile coring

A random selection of piles at the western beach end, the intertidal zone and near the abutment were cored. These were at Piers 3, 8, 11, 74, 76, 77, 86, 109, 110 and 113. The location of Piers is shown in Figure 5. Photos of the cores are shown in Appendix A.

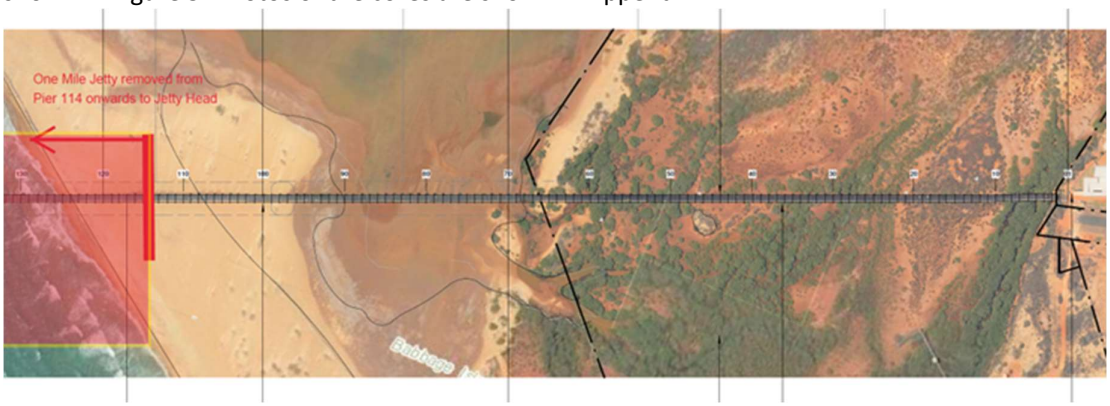

Figure 5: Jetty showing Pier Numbers - Pier 1 is at the abutment - Pier 114 is the extent of the remaining jetty

Since the time of deconstruction of the jetty, the beach at the western end had eroded such that Piers 109 to 114 were now in the water.

Evidence of Teredo was found in the cored piles in the beach area however there was little evidence of marine borers in the Piers within the mangrove area near the abutment. This is likely because the coring did not intercept the historic zone likely affected by marine borers when there was no siltation, i.e., that portion of pile that was previously in the water column as shown in Figure 3. As previously stated, marine borers require both oxygen and water to thrive.

Photo 9: Limited core extracted from Pier 110 showing evidence of marine borers

Photo 10: Core from Pier 10. White head of dead Teredo can be seen in the cavity created by the borer

Access to some areas in the intertidal area between bents 70 and 100 was difficult due to the soft ground conditions. Photos below show than many piles in this area are in poor condition and therefore have little or no structural capacity.

Photo 11: Split and rotted pile in intertidal zone - replacement steel pile alongside is corroded.

Photo 12: Split original pile which has been spliced with new upper section. Splicing supports either side showing evidence of marine borers.

4 Other Structural Issues

While undertaking the pile coring other defects were noted as follows:

- Cracked or split crossheads
- Missing or rotted cross bracing
- Missing or rotted lower waler
- Split corbels
- Corroded bolted connections
- Historic evidence of white ant damage (no longer active)
- Badly weathered deck planks
- Handrailing in various condition including missing sections.

4.1 Crossheads

Some split or cracked crossheads have been strengthened by underslung steel structural member as shown in Photo 13 and Photo 14. Replacing a crosshead in the mangrove area can be problematic due to access constraints.

Photo 13: Cracked crosshead strengthened by underslung steel member

Photo 14:: Cracked crosshead strengthened by underslung steel member

4.2 Cross Bracing and Lower Walings

Given the likelihood of Teredo infestation for the pile section originally or currently within the water column which reduces the pile capacity, cross bracing is vitally important to maintain any structural integrity. If any of the jetty is to be maintained, then the cross bracing must be replaced or reconnected as appropriate.

Photo 15: Incomplete cross bracing and cracked crosshead

Photo 16: No cross bracing in 3 consecutive bays

Photo 17: Rotted lower waler and pile

Photo 18: Disconnected lower waler

4.3 Corbels and Stringers

Most of the corbels which support the stringers are split due to the corrosion of the bolts securing the stringers to the corbels. It would be a difficult task to replace a corbel as it would likely require the removal of a portion of the deck and the installation of temporary supports under the stringers. This would be considered necessary in any area subject to uplift from cyclonic waves. As this is unlikely to occur in the region of the abutment (Piers 1 to 60) an alternative strategy may be the removal of the corroded bolt and inserting cross bolts through the corbel to clamp the split before renewing the bolt securing the stringer to the corbel.

Most of the stringers are in good condition except for the stringers on the northern face which are heavily weathered. Many Stringers (beams) and corbels were replaced or supplemented with additional beams in the 1950's. The need for the replacement is not known however at that time jetty deck loading would have been higher than that required for pedestrian purposes.

Photo 19: Typical split corbel due to corroded bolts

Photo 20: Weathered Stringers (Beams) on the northern side

4.4 Corroded Fastenings

The degree of corrosion to the bolts varies and, in many cases, the corroded bolts expand and cause the timber to split – particularly in relation to the crossheads. Various reconstruction plans state that bolts should be either cadmium plated, coated with lanolin, or wrought iron. Drawing PWD.WA 26741 dealing with the reconstruction of the Jetty head stated that all bolts below MHW should be Muntz Metal (also known as yellow metal) which is an alpha-beta brass alloy composed of approximately 60% copper, 40% zinc and a trace of iron. A corroded bolt taken from the lower section of a replaced pile exhibited unusual corrosion whereby the bolt corroded internally and left a hollow outer casing as shown in Photo 22.

Photo 21: Corroded bolts inside a rotted cut off pile

Photo 22: Unusual corrosion mechanism of bolt

4.5 Termite Damage

Although there is evidence of termite activity it does not seem to be active, and damage is minimal.

Photo 23: Termite damage to crosshead

4.6 Deck Planks

Deck planks are badly weathered or broken. The uneven surface presents a continuous trip hazard, particularly for the disabled. Should a section of the jetty be retained then the entire decking in that section should be replaced. The practice of placing a concrete topping on the existing deck planks is not recommended in this instance as this would remove the ability to replace piling by driving a steel pile between the crossheads should pile replacement be necessary.

Photo 24: Split and weathered deck boards

Photo 25: Weathered deck boards

4.7 Handrailing

The handrailing (southern side only) is in various states of repair. The remaining timber is generally sound however fastenings should be replaced.

Photo 26: Broken handrailing

Photo 27: Missing handrailing

5 Conclusions

The condition of the jetty from Piers 70 to 114 is poor and beyond rehabilitation. The beach at the western end has eroded resulting in Piers 109 to 114 now being in the water. This section is now exposed to storm damage with the consequential risk that timbers may be dislodged and present a navigational hazard.

There is evidence that marine borers have weakened the piles in the tidal zone. Historically this may have also occurred in the section between Piers 1 and 70 prior to this area silting up. This area is now only inundated during periods of high tide and is protected from waves by the mangroves.

If a limited section of jetty is to be maintained as a timber structure for heritage purposes and for pedestrian access only then it will be necessary to replace the entire deck in this section as well as reinstate all cross bracing and lower waler. The cross bracing and lower waler will ensure the lateral structural stability of the structure given the likelihood that the upper portion of the buried section of the pile was previously in the tidal zone prior to siltation and therefore exposed to marine borers.

There has been a long history of the need to replace piles for various reasons. Up until 1960 50% of the piles from Pier 1 to Pier 70 had been replaced. The service life of the replaced piles to that time varied from 20 to 50 years. A further 60 years has passed since that time therefore there is a high probability that several piles will require replacement should it be decided to renew a portion of the jetty.

The loads on piles due to pedestrian loading only will be much reduced when compared to the original design loads, including environmental loads, due to the degree of siltation and protection from wave attack due to the mangroves. If the piles are rotted or damaged by marine borers then the environmental loads can be resisted by the bracing with minimal penetration requirements. Axial loads (pedestrians plus dead load) will be resisted by skin friction and the reduced pile diameter. If there is insufficient remaining diameter or penetration the pile will sink and there will be a noticeable sag in the jetty in which case the pile must be replaced.

Any repairs to the substructure will be costly due to presence of mangroves and the difficulty of access. The length of jetty that could be refurbished for heritage purposes will depend upon the availability of funds and the amount of salvaged usable timber that has been retained. Large timber sections are now difficult to source.

6 References

Carnarvon One Mile Jetty - Damage Assessment Post Cyclone Seroja - 21st & 22nd April 2021, Trinacria Consulting Report 2021/0401

PWD.WA 25272 – Carnarvon Jetty, Pile Record Diagram

PWD.WA 28794 Carnarvon Jetty, Siltation Soundings Along Jetty

PWD.WA 36242 Carnarvon Jetty Layout of Beams (Repairs 1958)

PWD.WA 16153 Carnarvon Jetty, Plan Showing Pile Renewals etc.

7 Limitations

Trinacria Consulting has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Department of Transport and only those third parties who have been authorised in writing by Trinacria Consulting to rely on the report.

The report is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the agreed scope of work (pile design for floating pens).

The methodology adopted, and sources of information used by Trinacria Consulting are outlined in this report. Trinacria Consulting has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions.

This report was prepared in August 2022 and is based on the information reviewed at the time of preparation.

APPENDIX A – PILE CORE PHOTOS




Photo 28: Pier 45 Core



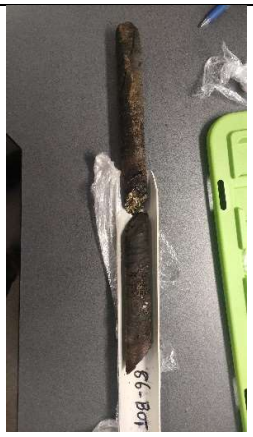




Photo 29: Pier 113 Core